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ABSTRACT

A study was designed to evaluate whether congruency or incongruency between a teacher's intended discovery/inquiry laboratory instructional strategy and his/her actual behaviors used to implement that strategy had an effect on higher level learning by students. Also assessed was whether student performance on science projects can be an effective means to discriminate previously undetected student differences in higher level cognitive abilities relative to the understanding and use of science processes. Four class sections of high school biology students (N=72) were established. Two sections were treated by an instructor employing congruent laboratory verbal behavior, while the remaining two sections received incongruent laboratory verbal treatment. Judgments concerning the effects of contrasting teacher verbal behavior during the laboratory sessions were made on the student's performance in designing and developing science projects after 24 weeks of experimental instruction. Results include the findings that subjects did not differ statistically in mean score performance in the two teacher laboratory verbal treatments, and that the congruent treatment subjects earned significantly higher mean scores in cognitive abilities relative to the understanding and use of science processes. (CS)

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The Comparative Effects of Congruent and Incongruent Teacher Verbal Behavior on Higher Level Learning Outcomes of Secondary Biology Students during Discovery/Inquiry Laboratories.

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Purpose & Objectives

Since the introduction of the new curricula in the 1960's, the focus and function of the laboratory have changed, and today, the "cookbook" laboratories associated with traditional science courses presenting highly directed activities designed to verify textbook information have given way in many schools to activities intended to provide the student with experiences that will aid him in understanding the processes of science itself. Shulman and Tamir (1973) acknowledge, however, that this shift in role has not been based on empirical data but on the opinions of the leading figures who took part in the development of the new curricula. Even though the rationale for this shift in emphasis has been "improved learning", research does not appear to support the rationale. Even a cursory examination of the literature investigating the laboratory approaches to science education reveals that laboratory experiences, when compared to other strategies and modes of instruction, yield no significant differences in student learning of facts and principles (Ramsey and Howe 1969; Shulman and Tamir 1973; and Bates 1978).

Initially, if the major intent of laboratory instruction in science education today is to bring students to some level of competence in understanding the nature of the scientific enterprise, the achievement of that competency should be the basis for conclusions concerning laboratory effectiveness and not the assessment of pupils' knowledge of facts and principles which reflect the products rather than the nature of science. Rowe (1978) suggests that if science educators expect learners to get more than basic concepts from laboratory experience, then they need to be explicit about which outcomes are important and how achievement of those

outcomes is being assessed. Robinson (1979) points out that evaluation needs to be appropriate for different educational approaches or methodologies of teaching and learning. The laboratory is, indeed, a "different" educational approach possibly offering something "unique" to the learner. Consequently, more attention should be given to the evaluation of specific laboratory learning in studies of laboratory effectiveness.

Almost without exception current researchers examining laboratory effectiveness appear to have relied heavily upon the evaluation of students' achievement of lower cognitive levels as identified through conventional paper and pencil tests. The questionable method and purpose of assessing these low cognitive skills represents little, if any, evidence for assuming any relevance to the achievement of higher level cognitive outcomes which are held to be the objectives of science education. The current misfocused research has led to a search for alternative methods of evaluating the laboratory which would focus on the achievement of higher cognitive level skills.

More importantly, studies on laboratory effectiveness lack measures to ascertain what sorts of interactions are actually taking place in the name of discovery learning. There has been a great deal of discussion concerning the degree to which science teachers have made the transition from the traditional content approach to the scientific process approach. Indeed, appropriate teacher behavior in contemporary science education is suspect, considering teacher attitudes toward and understanding of science as an inquiry process (Herron 1971; and Lazarowitz and Lee, 1976). A study by Beam and Horvat (1975) revealed that science teachers think they are running a more inquiry, indirect and student-oriented classroom than they actually are. More specifically, even in instructional environments

which claim the appellation of laboratory, many teachers devote less than one percent of laboratory time to asking students for opinions, hunches or evaluations (Parakle 1965).

Ramsey and Howe's (1969) review of instructional outcomes associated with the national curriculum projects suggests that it is possible to design laboratory-centered instruction oriented toward inquiry and problem solving. They make it clear, however, that teacher characteristics are probably more critical than the particular curriculum materials employed in the laboratory and that instructional style of the teacher must be congruent with the objectives and methods of curriculum. Numerous studies indicate that the type of instruction does effect student learning and that the teacher is the most important variable (De Rose, Lockard and Paldy 1979).

As a result of this review and evidence which do not support the laboratory as a valuable adjunct to science instruction, these investigators have decided to center their study around the effect of congruent and incongruent teacher verbal behaviors on student achievement of the higher level learning outcomes generally associated with the high school biology laboratory.

The purpose of this study was to evaluate whether congruency or incongruency between a teacher's intended laboratory instructional strategy and actual verbal behaviors used to implement discovery/inquiry laboratory investigations had an effect on higher level laboratory learning by pupils as reflected through the analysis of student science projects. The question was "Can students better understand and use the processes of science as a result of the instructor employing verbal examination behaviors that are congruent with the convergent discovery and divergent inquiry nature of contemporary laboratory objectives?"

For this study the hypotheses are listed below in the null form; therefore, the conclusions will be based on statistical procedures which will reject or retain the null hypotheses:

1. There is no significant difference ($p<.05$) in mean scores of the students in the contrasting treatment groups in terms of understanding the nature of science as measured by the Total score and four major element scales of the Science Process Inventory.

2. There is no significant difference ($p<.05$) in mean science project score performance as evaluated by The Science Project Evaluation Criteria among the students in the contrasting treatment groups.

3. There is no significant difference ($p<.05$) in mean scores among the students in the contrasting treatment groups in terms of pupil attitudes toward science as measured by the Allison Adaptation of the Allen Attitude Scale.

Methodology and Procedure

The subjects in this study were selected randomly from a population of one hundred and seventeen high school students scheduled to take their first course in high school biology. All of the subjects had a similar background in science education in terms of Stanford Achievement Test Scores, teacher recommendations and pupil preferences as indicated by their selection of courses.

Six class sections were established, and the students were randomly selected from the population originally enrolled in the course. They were assigned to the sections by use of a table of random numbers. By using the flip side of a coin, four sections were selected and two class sections were assigned to each of the two treatment groups. The sample for the study was grouped as listed below in Figure 1.

Section	Period	Number of Pupils	Treatment: Congruent Examination	Treatment: Incongruent Expository
1	2	18	x	
2	3	18		x
3	5	18	x	
4	6	18		x

An x indicates the mode of teacher verbal behavior employed during discovery/inquiry laboratory investigations.

FIGURE 1

THE ASSIGNMENT OF STUDENTS TO THE DIFFERENT MODES OF TEACHER VERBAL BEHAVIOR

The experimental design of this study was the Solomon Four-Group Design (Campbell and Stanley, 1963). Because of a "pretesting" tradition in the research setting, the randomized Solomon Four-Group Design was adapted in an effort to keep these measurements as nonreactive as possible. Two classes were used as the congruent examination group and the other two classes were used as the incongruent expository group. One-half of each class took the Science Process Inventory (SPI) pretest while the other half of each class took the Allison Adaptation of the Allen Attitude Scale (AAS) pretest. All of the students took SPI and AAS posttest at the end of the study. Figure 2 shows the Solomon Four-Group Design employed.

Subjects	Treatments: Congruent Method	Treatments: Incongruent Method
SPI Pretested	Group 1R N = 18	Group 2R N = 18
AAS Pretested	Group 3R N = 18	Group 4R N = 18

FIGURE 2

SOLOMON FOUR-GROUP DESIGN

The type of laboratory investigations examined was based upon the levels of laboratory strategies defined by Schwab's (1962) taxonomy:

Levels	Problems	Ways & Means for discovering relations	Answers
0	Given	Given	Given
1	Given	Given	Given
2	Given	Open	Open
3	Open	Open	Open

The specific laboratory strategies for which the teacher's verbal behaviors were contrasted were: 1. level one convergent discovery and 2. level two divergent inquiry types. This discovery/inquiry approach appears to be consistent with the learning outcomes attributed to laboratory experiences in contemporary secondary biological science education.

The level zero strategy was considered to be verifying in nature and not consistent with the higher level outcomes associated with contemporary laboratories. This type of investigation was valued as part of the non-laboratory instruction in this study. The level three strategy, while included in the research, was not viewed as an independent variable, but rather, as one of the dependent variables; pupil performance in the design and development of science projects which assess success between treatment groups.

During the discovery/inquiry laboratory investigations, the congruent treatment group experienced examination type teacher verbal behaviors and teacher questions beyond the knowledge and comprehension cognitive levels. The incongruent treatment group experienced didactic/expository type teacher

verbal behavior during the discovery/inquiry laboratory investigations and teacher questions were limited in number.

The teacher variable was controlled by using the same instructor for both treatments, and teacher performance was verified by the systematic analysis of audio-tape recordings of randomly selected laboratory activities. Aside from the differences in the instructor's verbal approaches during laboratory sessions, all treatment groups experienced the same basic course in terms of text, materials, unit, sequence, and lesson format.

Instruments and Data

Two groups were pretested using the Science Process Inventory and two groups were pretested using the Allison Adaptation of the Allen Attitude Scale.

Following twenty-four weeks of experimental instruction, judgements concerning the effects of contrasting teacher verbal behaviors during the laboratory sessions were made: First, Welch's Science Process Inventory was used to assess the student's understanding of the nature of science; second, the subject's performance when designing and developing science projects were measured by the Science Project Evaluation Criteria assessing cognitive abilities; third, Allison's Adaptation of the Allen Attitude Scale was used to assess the students' attitudes toward science, scientists, and scientific careers.

A two-way analysis of variance was employed for the analysis of treatments and type of pretests on the Science Process Inventory and the Allison

Adaptation of Allen Attitude Scale posttest scores; a two-way analysis of variance with repeated measures was used for the analysis of gain scores in pretest and posttest results of the Science Process Inventory and the Allison Adaptation of Allen Attitude Scale. Finally, the null hypothesis concerning pupil performance on science projects was tested by using an independent sample t-test for the analysis of the Science Project Evaluation scores. Selected computer programs developed by the Pennsylvania State University were used for all analyses of primary data.

Results And Conclusions

The findings resulting from testing of all three null hypotheses concerning the relative effectiveness of congruent and incongruent teacher verbal laboratory behaviors are as follows:

1. In the area of student's understanding of the nature of science, the five specific Null Hypotheses were retained at the .01 level of significance, thus retaining the Null Hypothesis #1 at the .05 level of significance. Therefore, the congruent laboratory treatment students and the incongruent laboratory treatment students on the Science Process Inventory "Total" score or the four major element subscale scores indicated no significant difference.

2. In the area of cognitive abilities utilized in the design and development of science projects, Null Hypotheses #2 was rejected at the .05 level of significance, indicating that the congruent treatment students performed significantly better than the incongruent treatment students in understanding and using the science process as demonstrated by the design and development of individual science projects.

3. In the area of scientific attitude, Null Hypotheses #3 was retained at the .05 level of significance. In other words, there was no significant difference in attitudes toward science, scientists and scientific careers as measured by the Allison Adaptation of Allen Attitude Scale.

Discussion

Several conclusions can be made regarding the problems investigated:

Initially, students who were identified as pretested and unpretested groups scored equally well on the Science Process Inventory regardless of the teacher laboratory verbal bahavior experienced. This result was constant whether total scores or any of the four subscale elements were employed, or whether mean scores or adjusted mean scores were used. This finding indicates that there was no significant pretest effect on the posttest. Therefore, the posttest scores of both treatment groups could be interpreted as reflecting the students' understanding of the process of science after twenty-four weeks of experimental laboratory instruction.

Secondly, there were no significant interactions between subjects identified as pretested and unpretested and the treatment, either congruent or incongruent, on all comparisons.

Third, the two verbal laboratory treatments, congruent and incongruent, were similarly effective in facilitating the understanding of the process of science. This finding is consistent with other research in the area of laboratory effectiveness reported by Yager, Englen and Snider (1969), Pella and Sherman (1969), M. Smith (1971) and Oliver (1975)

at the secondary level. In addition, at the college level laboratory-related research by Zingaro and Collette (1968) and Speers and Zollman (1977), comparing laboratory approaches, failed to identify any significant difference in understanding the process of science.

Finally, there was significant improvement between respective pretest and posttest scores on the Science Process Inventory "Total" score and an "Activities" subscale element score. Although the gains in understanding the scientific enterprise of the subjects were significant, there was no significant difference between the two treatment methods.

As a result of these findings it may be inferred that regardless of the instructor's verbal approach to laboratory instruction, there are no significant differences in understanding the process of science. These findings appear to endorse other studies cited earlier which report on selected paper-and-pencil instruments which measure students' knowledge about the nature of science. The suggestion is that neither standard laboratory practices nor operationally explicit teacher verbal behaviors in discovery/inquiry laboratories enhance nor detract from pupil performance on these measures.

In the area of cognitive abilities relative to the understanding and use of the processes of science, the congruent treatment group students scored significantly higher than the incongruent treatment group students on the Science Project Evaluation Criteria. Considering the mixed results of laboratory effects and statements of Jungwirth (1970) and Tamir (1972) who question the use of recognition-type items and written examinations to evaluate the constructive and practical cognitive aspects of doing science, the higher scores by the group experiencing congruent treatment implies

that evaluation of student performance on the design and development of science projects can be an effective means for discriminating student differences as a result of comparing laboratory approaches.

Moreover, it appears that the cognitive abilities associated with the process of science as measured by learner performance on science projects cannot be acquired in any deep and meaningful way by listening and observing others perform. It appears that the learner must be meaningfully involved in the intellectual effort and the thinking opportunities the laboratory can provide. If the major intent of laboratory instruction in science education today is to bring learners to some level of competence in understanding the nature of the scientific enterprise and learner performance on science projects is a valid means of measuring achievement of that competency, then it appears as a result of this research that teacher verbal behavior during discovery/inquiry laboratory investigations is a relevant and important variable.

It is apparent that studies examining student achievement of the skills associated with scientific inquiry must consider the teacher's verbal behavior as a cognitive process in science laboratory instruction. The effective acquisition of the cognitive abilities such as using known concepts for defining problems, formulating hypotheses, designing ways and means to test those hypotheses, analyzing data, drawing inferences and relating findings appear to be enhanced by the teacher's verbal behavior that permits the learner to experience the thinking opportunities the laboratory is designed to provide. This opinion is consistent with Bruner's (1961 & 1963) argument that the effective learning of the process of science cannot take place in situations where students are not permitted to take an active part in the formulation of ideas or to play a

meaningful role in the learning activities. Strasser, et al. (1971) agree that inquiry learning situations are those in which the student, not the instructor, carries the main burden of intellectual effort. Furthermore, Tamir (1977) describes the uniqueness of the laboratory as that of being able to provide students with opportunities to engage themselves in the process of investigation and inquiry. Science Educators who feel that the laboratory offers something special, in terms of activities and outcomes, for students may do well to consider what those activities and outcomes are, and what level of laboratory organization and modes of instruction may most likely facilitate achievement of those objectives.

Finally, it is obviously possible to design laboratory-centered instruction oriented toward inquiry. Yet frequently ignored in this design is the control of the teacher's verbal behavior, even though it is probable that his/her behavioral characteristics are just as critical as the curriculum materials employed in the laboratory. It seems then, that if the opportunity for behavioral changes in learners is to be maximized, congruence between teacher's verbal instructional behavior and expected learning outcomes must be considered.

In the area of students' attitudes towards science, scientists and scientific careers, a number of observations can be made. First, students who were identified as pretested and unpretested scored equally well on the Allison Adaptation of the Allen Attitude Scale regardless of the teacher laboratory verbal behavior experienced. This result suggests that there was no significant pretest effect on the posttest. Therefore, the posttest scores on the tests of both treatment groups were reflecting the students' attitude toward science, scientists and scientific careers after twenty-four weeks of experimental laboratory instruction.

Secondly, there was no significant interaction between subjects identified as pretested and unpretested and the treatment, either congruent or incongruent.

Next, the two verbal laboratory treatments, congruent and incongruent, were similarly ineffective in facilitating changes in attitudes toward science, scientists and scientific careers. This finding is parallel to the studies of laboratory effectiveness by Pella and Sherman (1969) and by Yager et al. (1969) in the area of learner attitudes toward science. It is inconsistent with other studies such as Coulter (1966), Sorenson (1966) and Bybee (1970) who report significant gains in attitudes as a result of their research concerning laboratory learning.

Finally, there was no significant difference between respective pretest and posttest scores on the Allison Adaptation of the Allen Attitude Scale regardless of the treatment method.

As a result of these findings in the area of attitudes toward science, it may be inferred that regardless of the laboratory experience or the instructor's verbal approach to that experience, there are no significant differences in attitude change. One must be cautious in this area; since Bates (1978) maintains that efforts to assess pupil attitudes suffer "major methodological and instrumentation limitations." Measures far more sensitive than currently exist may be required to examine laboratory related attitudes (Shulman and Tamir, 1973).

Because of this and the limitation of the experimental period of twenty-four weeks, to definitely attempt to assess changes in attitude toward science was questionable.

Recommendations for Further Research

The following results from the discussion and implications of findings are offered for further research as extensions of this study:

1. Research that is concerned with the definition and validation of goals of contemporary science laboratory education should be conducted in order to identify learning outcomes which may be clearly associated with the laboratory.

2. In light of the lack of a generally accepted instrument or procedure for assessing student outcomes as a result of laboratory experiences, research to develop and validate a "non-paper-and-pencil" evaluation measure to assess levels of achievement of cognitive skills and abilities related specifically to laboratory learning should be carried out.

3. As a result of the informal observations made during this study, research identifying the effects of science project design and development on students should be conducted to assess these activities impact on science learning outcomes.

4. A study should be completed comparing the effects of congruent and incongruent teacher verbal laboratory behavior relative to the "laboratory structure and task analysis inventory" of Lunetta and Tamir (1979 & 1978).

5. Studies should be conducted which employ descriptive ethnographic methods to examine the teacher-pupil interaction in the science laboratory to generate more qualitive information to accompany quantitive data already collected.

6. Replication of this type of study assessing the implications of the instructor's verbal laboratory behavior on Piagetian levels of learner cognitive development should be completed.

REFERENCES

Bates, G. C. "The Role of the Laboratory in Secondary School Science Programs." What Research Says to the Science Teacher, Mary Budd Rowe (ed.), Vol. 1, National Science Teachers Association: Washington, D. C., 1978.

Beam, K. J., and Horvat, R. E. "Differences among Teachers' and Students' Perceptions of Science Classroom Bahaviors, and Actual Classroom Bahaviors." Science Education, 1975, 59, 333-334.

Campbell, D. T., and Stanley, J. C. "Experimental and Quasi-Experimental Designs for Research." Handbook of Research on Teaching. Nathaniel D. Gage (ed.), Chicago: Rand McNally College Publishing Company, 1963.

DeRose, J. W., Lockard, J. D., and Paldy, L. G. "The Teacher is the Key: a Report on Three N.S.F. Studies." The Science Teacher, 1979, 49, 31-37.

Herron, M.D. "The Nature of Scientific Inquiry." School Review. February 1971, 12, 171-212.

Lazarowitz, R., and Lee, A. E. "Measuring Inquiry Attitudes of Secondary Science Teachers." Journal of Research in Science Teaching, 1976, 13, 455-460.

Parakh, J. S. "To Develop a System for Analyzing the Reactions of Teachers and Students in Biology Classes." Cooperative Research Project, No. S-269, Cornell University, Ithaca, New York, 1965. (ERIC Document Reproduction Service No. ED C10 608)

Ramsey, C., and Howe, R. "An Analysis of Research on Instruction Procedures in Secondary School Science, Part I: Outcomes of Instruction." The Science Teacher, 1969, 36, 62-70.

Robinson, J. T. "A Critical Look at Grading and Evaluation Practices." What Research Says to the Science Teacher, Mary Budd Rowe (ed.), Vol. 2, National Science Teachers Association: Washington, D. C., 1979.

Rowe, M. B. (ed.) What Research Says to the Science Teacher, Vol. 1. National Science Teachers Association: Washington, D. C., 1978.

Schwab, J. J. "The Teaching of Science as Enquiry" in J. J. Schwab and P. Brendwein, The Teaching of Science. Cambridge, Mass.: Harvard University Press, 1962.

Shulman, L. S., and Tamir, P. "Research on Teaching in the Natural Sciences." In Second Handbook of Research on Teaching: Chapter 34, pp 1098-1142. Robert M. W. Travers (ed.), Chicago: Rand McNally and Company, 1973.

Bruner, J. S. "The Act of Discovery." Harvard Educational Review, 1961, 31, 21-32.

Bruner, J. S. "Structure in Learning." NEA Journal, National Education Association, March 1963, 52(3), 26-27.

Bybee, R. "The Effectiveness of an Individualized Approach to a General Education Earth Science Laboratory." Science Education, April-June 1970, 54, 157-161.

Coulter, J. "The Effectiveness of Inductive Laboratory, Inductive Demonstration, and Deductive Laboratory in Biology." Journal of Research in Science Teaching, 1966, 4, 185.

Jungwirth, E. "An Evaluation of the Attained Development of Intellectual Skills Needed for Understanding the Nature of Scientific Inquiry by B.S.C.S. Pupils in Israel." Journal of Research in Science Teaching, 1970, 7, 141-151.

Lunetta, V. N., and Tamir, P. "Matching Lab Activities with Teaching Goals." The Science Teacher, 1979, 46, 22-24.

Oliver, M. "The Efficiency of Three Methods of Teaching High School Biology of Lecture-Discussion, Lecture-Discussion and Demonstration in combination with Laboratory Exercises." Journal of Experimental Education, 1975, 33, 289-298.

Pella, M., and Sherman, J. "A Comparison of Two Methods of Utilizing Laboratory Activities in Teaching the Course UPS." School Science and Mathematics, April 1969, 69, 303-313.

Smith, M. O. "A Comparison of Two Laboratory Methods for the Teaching of General Physical Science at the College Level: Vicarious Experimentation Versus Conventional Experimentation." Unpublished Doctoral Dissertation, The Pennsylvania State University, 1971.

Sorenson, L. L. "Change in Critical Thinking Between Students in Laboratory- Centered and Lecture-Demonstrated-Centered Patterns of Instruction in High School Biology." Dissertation Abstracts 26: May, 1966, 6567-6568.

Spears, J., and Zollman, D. "The Influence of Structured Versus Unstructured Laboratory on Students' Understanding the Process of Science." Journal of Research in Science Teaching, 1977, 14, 33-38.

Strasser, B. B., et al. Teacher Toward Inquiry. Washington: National Education Association, 1971.

Tamir, P., and Lunetta, V. N. "An Analysis of Laboratory Inquiries in the BSCS Yellow Version." The American Biology Teacher, September 1978, 40(6), 353-357.

Tamir, P. "How are the Laboratories Used?" Journal of Research in Science Teaching, 1977, 14, 311-316.

Yager, R. E., Englen, H. B., and Snider, C. F. "Effects of the Laboratory and Demonstration Methods upon the Outcomes of Instruction in Secondary Biology." Journal of Research in Science Teaching, 1969, 6, 76-86.

Zingaro, J., and Collette, A. "A Statistical Comparison Between Inductive and Traditional Laboratories in College Physical Science," Journal of Research in Science Teaching, 1968, 5, 269-275.

ABSTRACT

The purpose of this study was to evaluate whether congruency or incongruency between a teacher's intended discovery/inquiry laboratory instructional strategy and his actual behaviors used to implement that strategy had an effect on higher level learning by students.

The mixed findings of earlier research on the effects of laboratory instruction on pupil learning and the suspicion that teachers do not, in fact, conduct discovery-inquiry strategies as intended encouraged this author to examine teacher's verbal behavior during science laboratory instruction. Existing studies appear to avoid varifying what sorts of interactions are actually occuring under the label of "laboratory experience." Hence, it appeared necessary to question whether the teacher's verbal behavior during science laboratory instruction is a relevant variable when determining the effect of science laboratory instruction on students' higher level learning.

Aside from the question of importance of congruent and incongruent instruction, two additional problems remained: did the earlier research evaluate the appropriate higher level learning outcomes; and was the method of evaluating laboratory learning appropriate for assessing that learning. Consequently, this study assessed whether student performance on science projects can be an effective means to discriminate previously undetected student differences in higher level cognitive abilities relative to the understanding and use of science processes.

The seventy-two subjects used in this study were selected randomly from a population of high school students scheduled to take their first course in high school biology. Four class sections were established and two sections were treated by an instructor employing congruent laboratory verbal behavior while the remaining two sections received incongruent teacher laboratory verbal treatment. The experimental design was the Solomon Four Group Design. Four groups were developed. Two groups were pretested using the Science Process Inventory, and two groups were pretested using the Allison Adaptation of the "Allen Attitude Scale." Congruent and incongruent teacher verbal behaviors during

laboratory sessions were assigned and subsequently assessed by the systematic analysis of audio-tape recordings of randomly selected laboratory sessions.

Following twenty-four weeks of experimental instruction, judgements concerning the effects of contrasting teacher verbal behaviors during the laboratory sessions were made on the student's performance designing and developing science projects and measured by the Science Project Evaluation Criteria; Welch's Science Process Inventory; and the Allison Adaptation of the "Allen Attitude Scale".

A two-way analysis of variance was employed for the analysis of treatments and type of pretests on the Science Process Inventory and the Allison Adaptation of Allen Attitude Scale" posttest scores; and a two-way analysis of variance with repeated measures was used for the analysis of gain scores in pretest and posttest results of the Science Process Inventory and the Allison Adaptation of "Allen Attitude Scale." Finally, the null hypothesis concerning pupil performance on science projects was tested using an independent sample t-test for the analysis of the Science Project Evaluation scores.

Based on the .05 level of significance, the following findings are reported:
(1) The subjects, regardless of the teacher laboratory verbal treatment did not differ statistically in mean score performance on understanding science as measured by Welch's Science Process Inventory or on scientific attitudes as measured by Allen Attitude Scale.
(2) The congruent treatment subjects earned significantly higher mean scores in cognitive abilities relative to the understanding and use of science processes as measured by the Science Project Evaluation Criteria than did the incongruent treatment subjects.